14. *TUCTORIA GREENEI* (GREENE'S TUCTORIA)

a. Description and Taxonomy

Taxonomy.—The genus *Tuctoria* is in the grass family (Poaceae), subfamily Chloridoideae, and is a member of the Orcuttieae tribe, which also includes *Neostapfia* and *Orcuttia* (Reeder 1965, Keeley 1998). Vasey (1891:146) originally assigned the name *Orcuttia greenei* to this species, from a type specimen collected in 1890 "on moist plains of the upper Sacramento, near Chico, California," presumably in Butte County (Hoover 1941, Crampton 1958). Citing differences in lemma morphology, arrangement of the spikelets, and other differences (see "Description" below), Reeder (1982) segregated the genus *Tuctoria* from *Orcuttia* and created the new scientific name *Tuctoria greenei* for this species. Subsequent research suggests that *Tuctoria* is intermediate in evolutionary position between the primitive genus *Neostapfia* and the advanced genus *Orcuttia* (Keeley 1998, L. Boykin *in litt.* 2000). Several other common names have been used for this species, including Chico grass (Scribner 1899), awnless Orcutt grass (Abrams 1940), Greene's orcuttia (Smith *et al.* 1980), and Greene's Orcutt grass (California Department of Fish and Game 1991, U.S. Fish and Wildlife Service 1985*c).*

Description and Identification.—The basic characteristics pertaining to all members of the Orcuttieae were described above in the *Neostapfia colusana* account. The genus *Tuctoria* is characterized by flattened spikelets similar to those of *Orcuttia* species, except that the spikelets of *Tuctoria* grow in a spiral, as opposed to a distichous, arrangement. *Tuctoria* species have short-toothed, narrow lemmas. The juvenile and terrestrial leaves of *Tuctoria* are similar to those of *Orcuttia*, but *Tuctoria* does not produce the floating type of intermediate leaves (Reeder 1982, Keeley 1998). *Tuctoria* appears to be intermediate between *Neostapfia* and *Orcuttia* in its degree of aquatic specialization (Keeley 1998).

Tuctoria greenei (**Figure II-18**) grows in tufts of several stems, which are erect or decumbent and break easily at the base. The entire plant tends to be pilose, but is only slightly viscid. The stems are usually 5 to 15 centimeters (2.0 to 5.9 inches) tall and are not branched. *Tuctoria greenei* has purplish nodes and leaves no wider than 5 millimeters (0.20 inch). The inflorescence can be as much as 8 centimeters (3.1 inches) long; it may be partly hidden by the leaves when young, but is held above the leaves at maturity. The inflorescence usually consists of 7 to 15 spikelets, but may contain as many as 40. The spikelets are arranged in a spiral, with those in the upper half crowded together and those near the base more widely separated. Each spikelet consists of 5 to 15 florets and 2 glumes. The lemmas are 4 to 5 millimeters (0.16 to 0.20 inch) long and have squarish tips with 5 to 9 very short teeth; the central tooth is tipped by a very small spine. The

roughened seeds are about 2 millimeters (0.08 inch) long (Vasey 1891, Hoover 1941, Griggs 1977*b*, Stone *et al.* 1988, Reeder 1982) and weigh about 0.5 milligram (1.8×10^{-5} ounce) (Griggs 1980). *Tuctoria greenei* has a diploid chromosome number of 24 (Reeder 1982).

Tuctoria greenei is differentiated from Orcutt grasses by the spiral arrangement of spikelets and lack of floating juvenile leaves, from *Neostapfia colusana* by the shape of the spikelets and the inflorescence, and from both by the shape of the lemmas. *Tuctoria greenei* can be distinguished from *T. mucronata* by the squarish lemma tip; smaller, roughened seeds; and inflorescence held above the leaves in the former. Both can be told from the remaining *Tuctoria* species by stem length, seed shape, and range. The chromosome number of *T. greenei* also differs from the other two species in the genus (Reeder 1982).

b. Historical and Current Distribution

Historical Distribution.—After its initial discovery in Butte County in 1890, *Tuctoria greenei* was not reported again for over 40 years. However, during extensive surveys in the late 1930s, Hoover (1937, 1941) found the species at 12 sites in Fresno, Madera, Merced, San Joaquin, Stanislaus, Tehama, and Tulare Counties (**Figure II-19**). In fact, he described it as the most common of all *Orcuttia* species, with which it was classified at the time.

Current Distribution.—*Tuctoria greenei* has been reported from a total of 41 occurrences in the original 8 counties listed above, plus Shasta County (Stone *et al.* 1988, Oswald and Silveira 1995, California Natural Diversity Data Base 2005). About half of the historical occurrences of *Tuctoria greenei* are presumed to be extant; 9 are certainly extirpated, and 10 others are possibly extirpated (Alexander and Schlising 1997, California Natural Diversity Data Base 2005). The majority of the 22 extant occurrences are in the Northeastern Sacramento Valley Vernal Pool Region, particularly in the Vina Plains. The next largest concentration is in the Southern Sierra Foothills Vernal Pool Region, where the only remaining occurrences are in eastern Merced County. The other two extant occurrences are in Glenn (Oswald and Silveira 1995, J. Silveira *in litt.* 2000) and Shasta Counties (California Natural Diversity Data Base 2003); the former is in the Solano-Colusa Vernal Pool Region, and the latter is in the Modoc Plateau Vernal Pool Region (Keeler-Wolf *et al.* 1998). *Tuctoria greenei* is believed extirpated from Fresno, Madera, San Joaquin, Stanislaus, and Tulare Counties (Stone *et al.* 1988, Skinner and Pavlik 1994, California Natural Diversity Data Base 2003).

Figure II-18. Illustration of *Tuctoria greenei* (Greene's tuctoria). Reprinted with permission from Abrams (1940), Illustrated Flora of the Pacific States: Washington, Oregon, and California, Vol. I. © Stanford University Press.

c. Life History and Habitat

The basic life history strategy and habitat requirements of *Tuctoria* species were described earlier in this document, under discussions for *Neostapfia colusana* and *Orcuttia inaequalis*.

Reproduction and Demography.—Optimum germination of *Tuctoria greenei* seed occurs when the seed is exposed to light and anaerobic conditions after stratification (Keeley 1988). Germination occurs about 2 months following inundation (Keeley 1998). *Tuctoria* seedlings do not develop floating juvenile leaves, as does *Orcuttia* (Griggs 1980, Keeley 1998). The plants apparently do not tolerate inundation; all five *T. greenei* plants in a Glenn County pool died when the pool refilled during late spring rains in 1996 (J. Silveira *in litt.* 1997). *Tuctoria greenei* flowers from May to July (Skinner and Pavlik 1994), with peak flowering in June and July (Griggs 1981, Broyles 1987).

As with other vernal pool annuals, population size in *Tuctoria greenei* varies widely from year to year, and populations that have no visible plants one year can reappear in large numbers in later years. Population fluctuations may be due to annual variations in weather, particularly rainfall, to changes in management, or combinations of the two. Such fluctuations were observed at scattered sites in Butte and Tehama Counties during the 1970s (Griggs 1980, Griggs and Jain 1983) and at Sacramento National Wildlife Refuge, where the population in the single occupied pool ranged from 0 to 60 plants between 1994 and 1999 (J. Silveira *in litt.* 2000). Fluctuations of as much as three orders of magnitude were documented on the Vina Plains Preserve during the 1980s and 1990s; the high 1995 population estimates followed a winter of favorable rainfall (Alexander and Schlising 1997) and a long period without livestock grazing. Cattle grazing on the Vina Plains Preserve was discontinued in the growing season of 1987 to 1988 and did not resume until the growing season of 1995 to 1996 (D. Alexander *in litt.* 1998).

Populations that decline to zero may not always be capable of rebounding from the soil seed bank, however, and the population is likely extirpated if the plants do not reappear under favorable conditions. One Stanislaus County population of *Tuctoria greenei* (Element Occurrence 39) numbered fewer than 100 plants in 1973, dropped to 2 the following year, and remained at 0 for the next 3 years (Griggs 1980, Griggs and Jain 1983). The population was not monitored for the following decade. Although the vernal pool was still intact as of 1986, *T. greenei* was not observed during surveys that year; however, the winter had been drier than average. In 1987, following a winter of favorable rainfall, *T. greenei* still was not present, even though *Neostapfia colusana* was found in large numbers.

Figure II-19. Distribution of *Tuctoria greenei* (Greene's tuctoria).

(Stone *et al.* 1988), indicating that *T. greenei* has most likely permanently disappeared from this site. The area had been "rather heavily grazed" in 1987 (Stone *et al.* 1988), but livestock grazing intensity during the 1970s is not known

In a demographic study conducted during 1977 to 1978 on two populations from Butte and Tehama Counties, from 0 to 54 percent of seedlings survived to maturity. Plants that reached the flowering stage achieved a density of 82 to 133 individuals per square meter (7.6 to 12.4 individuals per square foot) and averaged 111 seeds per plant (Griggs 1980, Griggs and Jain 1983). In 1995, the density of *Tuctoria greenei* on the Vina Plains Preserve ranged from 7 to 133 plants per square meter (0.7 to 12.4 plants per square foot) (Alexander and Schlising 1997).

A study of genetic partitioning in five species of *Orcuttia* and *Tuctoria* (Griggs 1980, Griggs and Jain 1983) revealed that *T. greenei* had the lowest genetic diversity (50 percent) of the species studied. As with the other species, plants originating from the same seed parent accounted for about the same degree of genetic diversity (44 percent) as others within the same population (46 percent). Only 10 percent of the total genetic variability observed in the species was due to between-population differences, indicating low levels of gene flow between populations, but high levels of gene flow within populations. However, Griggs' genetic study included only two populations from adjacent counties (Butte and Tehama) and did not consider geographically distant occurrences.

Habitat and Community Associations.—*Tuctoria greenei* has been found in three types of vernal pools: Northern Basalt Flow, Northern Claypan, and Northern Hardpan (Sawyer and Keeler-Wolf 1995) on both low and high terraces (Stone *et al.* 1988). Occupied pools are or were underlain by iron-silica cemented hardpan, tuffaceous alluvium, or claypan (Stone *et al.* 1988). Of pools where the species was known to be extant in 1987, the median size was 0.6 hectare (1.5 acres), with a range of 50 square meters (0.01 acre) to 3.4 hectares (8.4 acres) (Stone *et al.* 1988). Stone *et al.* (1988) noted that *T. greenei* grew in shallower pools than other members of the tribe or on the shallow margins of deeper pools, but they did not quantify pool depth. At the Vina Plains, *T. greenei* grew in pools of "intermediate" size, which dried in April or early May of 1995 (Alexander and Schlising 1997). The Central Valley pools containing *T. greenei* are (or were) in grasslands; the Shasta County occurrence is surrounded by pine forest (California Natural Diversity Data Base 2003). Occupied pools in the Central Valley are (or were) at elevations of 33.5 to 134 meters (110 to 440 feet) (Stone *et al.* 1988), whereas the Shasta County occurrence is at 1,067 meters (3,500 feet) (California Natural Diversity Data Base 2003).

In the Northeastern Sacramento Valley Vernal Pool Region, *Tuctoria greenei* grows mostly on Anita clay and Tuscan loam soils, with one occurrence on Tuscan stony clay loam. Soil types are not certain for several other occurrences in this region; one is on either the Rocklin or the San Joaquin series, and the others are unknown. The single occurrence in the Solano-Colusa Vernal Pool Region is on strongly saline-alkaline Willows clay (J. Silveira *in litt.* 2000). In the Southern Sierra Foothills Vernal Pool Region, *T. greenei* is known to grow on a number of different soil series including Archerdale, Bear Creek, Exeter, Meikle, Ramona, Raynor, Redding, and San Joaquin. Soil types have not been determined for occurrences in the other regions.

At the Vina Plains Preserve, frequent associates of *Tuctoria greenei* are *Eryngium castrense* and *Marsilea vestita* (Alexander and Schlising 1997). Elsewhere in the Sacramento Valley and in the San Joaquin Valley, *T. greenei* often grows in association with *E. vaseyi*, *Plagiobothrys stipitatus*, and *Alopecurus saccatus* (foxtail). The rare *Chamaesyce hooveri* co-occurs with *T. greenei* at eight sites in the Sacramento Valley. Other rare plants that grow in the same vernal pools with *T. greenei* at a few occurrences are: *Orcuttia pilosa*, *O. inaequalis*, *O. tenuis*, *Neostapfia colusana*, and *Gratiola heterosepala* (Broyles 1987, Stone *et al.* 1988, California Natural Diversity Data Base 2005).

d. Reasons for Decline and Threats to Survival

Most species addressed in this recovery plan are threatened by similar factors because they occupy the same vernal pool ecosystems. These general threats, faced by all the covered species, are discussed in greater detail in the Introduction section of this recovery plan. Additional, specific threats to *Tuctoria greenei* are described below.

One potential factor unique to this and some other vernal pool plant species may be decimation by grasshopper outbreaks. Grasshoppers have been noted consuming entire populations of *Tuctoria greenei* before they set seed (Griggs 1980, Griggs and Jain 1983, Stone *et al.* 1988). At the Vina Plains Preserve in Tehama County, the seed bank permitted some recovery after total destruction of the plants by grasshoppers. Sampling at one Vina Plains Preserve vernal pool in 1997 prior to a grasshopper event in 1998 showed that *Tuctoria greenei* had a frequency of 0.066 and a density of 26.3 plants per square meter (2.4 plants per square foot). In 1998 grasshoppers ate all of the plants and no seeds were produced. In 1999, 1 year after the grasshopper event, the same sampling showed a frequency of 0.025 and a density of 2.9 plants per square meter (0.27 plants per square foot) (R. Schlising *in litt*. 2005).

Primary threats to this species are also continuing. Agricultural conversion and inappropriate livestock grazing practices pose threats to virtually all of the occurrences remaining in the San Joaquin Valley, although one small population is on a site that has been proposed for protection as a mitigation bank (California Natural Diversity Data Base 2003). Fifteen populations of *Tuctoria greenei* throughout its range are subject to adverse effects related to cattle grazing (Stone *et al.* 1988, B. Corbin *in litt.* 2000, California Natural Diversity Data Base 2003). Small population size poses a continuing threat to seven occurrences in Butte, Glenn, and Merced Counties. Each of these populations numbered 110 or fewer *T. greenei* plants at its peak (Stone *et al.* 1988, California Natural Diversity Data Base 2005). The Shasta County population also may have declined to the point where it could be extirpated by random causes; although it consisted of 2,500 plants in 1993 and 1994, the population declined to 120 in 1996 and 35 in 1998, despite favorable hydrological conditions (B. Corbin *in litt.* 2000). Urbanization, including construction of a landfill, is a potential threat to the species.

e. Conservation Efforts

We listed *Tuctoria greenei* as endangered on March 26, 1997 (U.S. Fish and Wildlife Service 1997*a*). The State of California listed *T. greenei* as rare in 1979 (California Department of Fish and Game 1991), and the California Native Plant Society had recognized it as rare and endangered even earlier (Powell 1974). Currently, the California Native Plant Society (2001) includes *T. greenei* on List 1B, ranking it as "endangered throughout its range." In 2005, critical habitat was designated for *T. greenei* and several other vernal pool species in *Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions From August 2003 Final Designation; Final Rule* (U.S. Fish and Wildlife Service 2005).

Surveys by Hoover (1937, 1941) documented the historical range of *Tuctoria greenei*. Later surveys by Crampton (1959) and Medeiros (1976) revealed the destruction of various occurrences. The most recent, comprehensive survey (Stone *et al.* 1988) was funded by us to determine the status of *T. greenei* and related species. During the course of their surveys and related projects, Stone and others (1988) discovered four populations that were previously unknown. Research conducted by Griggs (1980) provided insights into the demography, ecology, and genetics of *T. greenei*, among other species. As part of his research, Griggs attempted to introduce *T. greenei* to two pools in Butte County, but the species never became established. Keeley (1988) conducted research on the conditions necessary for germination. We and the California Department of Fish and Game supported an ecological study of *T. greenei* and other rare species on the Vina Plains Preserve in 1995 (Alexander and Schlising 1997).

Six occurrences of *Tuctoria greenei* are on The Nature Conservancy's Vina Plains Preserve. This species has grown in as many as seven pools on the preserve in certain years (Stroud 1990, Alexander and Schlising 1997), including one pool on the Wurlitzer Unit (California Natural Diversity Data Base 2003). The Glenn County population, on the Sacramento National Wildlife Refuge, is the only occurrence known from public land.

15. *TUCTORIA MUCRONATA* (SOLANO GRASS)

a. Description and Taxonomy

Taxonomy.—Solano grass is in the Orcuttieae tribe of the grass family Poaceae (Reeder 1965). Solano grass was originally described under the name *Orcuttia mucronata*, based on specimens collected "12 miles due south of Dixon, Solano County" (Crampton 1959:108). Reeder (1982) transferred this species to a new genus, *Tuctoria*, resulting in the currently accepted name *Tuctoria mucronata*. Other common names are Crampton's Orcutt grass (Griggs 1977*b*), mucronate orcuttia (Smith *et al.* 1980), and Crampton's tuctoria (Skinner and Pavlik 1994).

Description and Identification.—Characteristics of the Orcuttieae were described earlier in this document under the *Neostapfia colusana* account and those common to the genus *Tuctoria* were presented in the *T. greenei* account. *Tuctoria mucronata* is grayish-green, pilose, and viscid. The tufted stems are decumbent, 12 centimeters (4.7 inches) or less long, and do not branch. The leaves are 1 to 4 centimeters (0.4 to 1.6 inches) long, are rolled inward, and have pointed tips. The inflorescence is 1.5 to 6 centimeters (0.6 to 2.4 inches) long, and its base is partially hidden by the uppermost leaves. As for all plants in this genus, the spikelets are arranged in a spiral; the 7 to 19 spikelets in the inflorescence of *T. mucronata* are crowded together. Spikelets range from 7 to 13 millimeters (0.28 to 0.51 inch) in length and consist of 5 to 10 florets, plus two glumes. The lemmas are 5 to 7 millimeters (0.20 to 0.28 inch) long and taper towards the tip, which is curved outward. The lemma teeth are not obvious except for the central one, which has a sharply pointed tip up to 1 millimeter (0.04 inch) long. *Tuctoria mucronata* has smooth seeds about 3 millimeters (0.12 inch) long and a diploid chromosome number of 40 (Crampton 1959; Reeder 1982, 1993).

Unlike *Tuctoria greenei*, the inflorescence of *T. mucronata* remains partly hidden by the leaves, even at maturity. In addition, *T. mucronata* stems are shorter than those of *T. greenei*, and the former has tapered lemmas and larger, smoother seeds. The spiral arrangement of the spikelets and single obvious tooth per lemma distinguish *T. mucronata* from the Orcutt grasses. Finally, the tapered